Using GIS data and satellite-derived irradiance to optimize siting of PV installations in Switzerland

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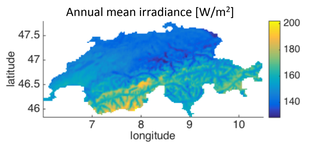
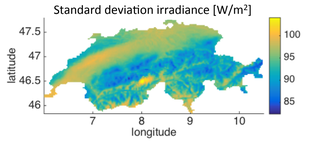
Background

- Swiss Energy 2050 strategy: Phase-out of remaining nuclear power plants → deficit in electricity production covered by renewables
- Challenge: Solar energy highly variable (diurnally, annually and due to cloud cover)
- Goal 1: Study different siting scenarios for PV installation and assess their impact on the power flow of the Swiss Electricity System
- Goal 2: Exploit spatial and temporal correlation of irradiance and demand under existing constraints to enable most robust production

Data

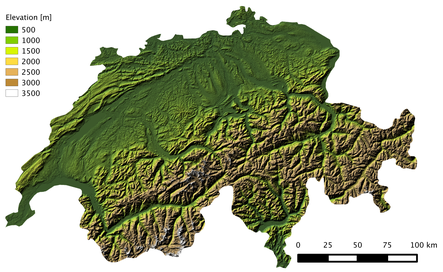
Solar irradiance from satellite imagery



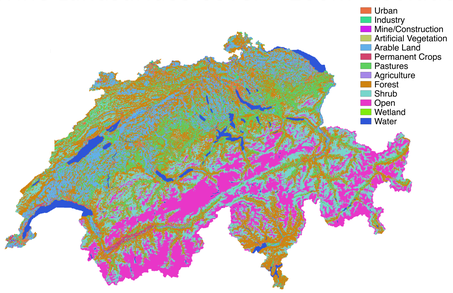


- 2004-2015, daily
- Surface incoming shortwave radiation (SIS)
- SEVIRI imagery using HelioMont algorithm (MeteoSwiss)
- Snow-cloud-discrimination
- Probabilistic cloud mask
- 1.6km x 2.3km resolution
- Self and terrain- shading

SRTM DEM – 30m resolution



Corine Landsurface Cover – 200m resolution



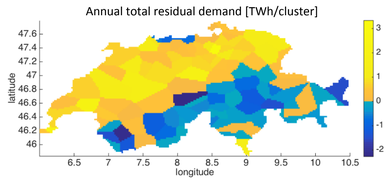
Additional data:

- Population density (SFSO)
- Swiss electricity demand + Infrastructure (swissgrid)
- Hydropower information (SFOE/WASTA, PREVAH)

Challenges in a renewable Switzerland

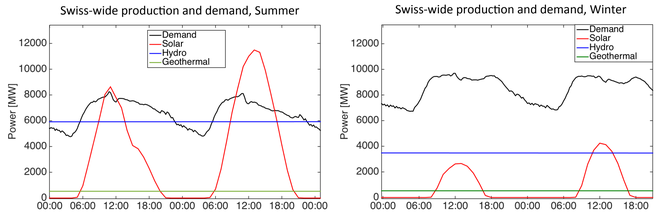
Mismatch in space:

- Demand centers in the north
- Hydropower production and solar potential primarily in the south
  → High regional residual demand
- Demand – Production

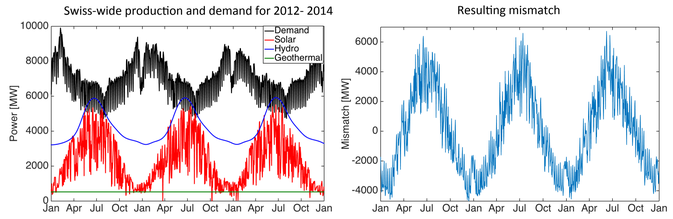


Mismatch in time:

1. Throughout the day

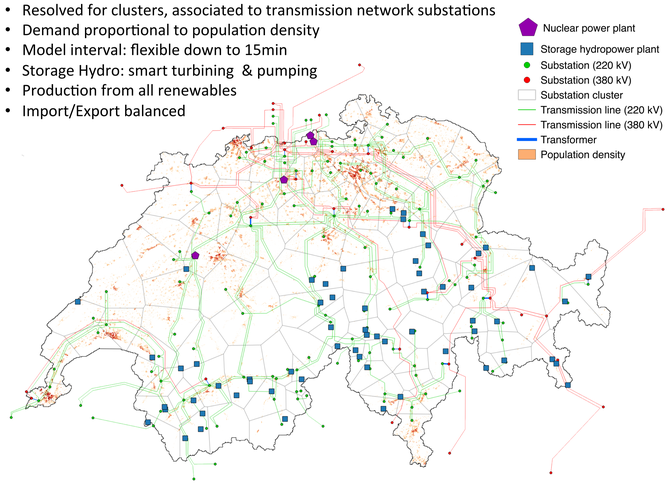


2. Throughout the year



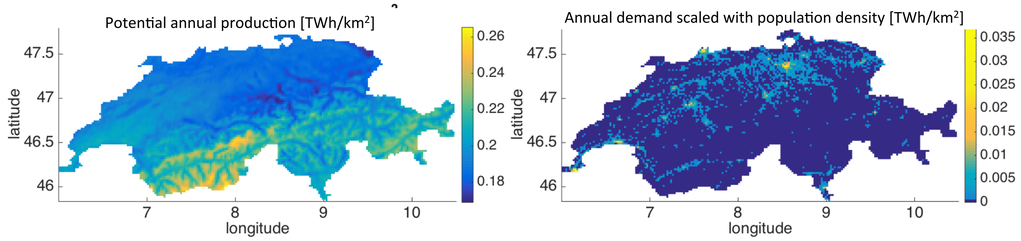
Assessment tool: Model of the Swiss electricity system

- Resolved for clusters, associated to transmission network substations
- Demand proportional to population density
- Model interval: flexible down to 15min
- Storage Hydro: smart turbining & pumping
- Production from all renewables
- Import/Export balanced



Different PV siting scenarios

to produce the 20TWh/year of electricity needed to satisfy current demand



Solar irradiance to electric power: 15% panel efficiency & different placement constraints

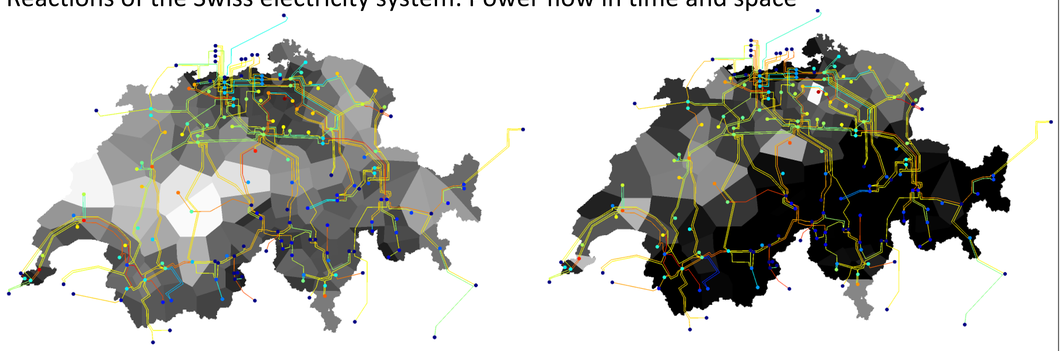
- Constraint 1: 15% of surface area in urban and 10% in industrial zones (total = 198km²)
- Constraint 2: Constraint 1 + 2% of agricultural and pastures (total = 570km²)

Always excluded: Lakes and zones above 2500m

Required surface area of installed PV for the different scenarios.

Scenarios	Sunniest pixels	Uniform coverage	Combo: 2/3 roof-top 1/3 PV farms	Cluster-wise scaled by population density	Cluster-wise scaled by residual demand
No constraint	82.9km²	101.1km²	-	-	-
Constraint 2	101.2km²	-	95.0km²	105.0km²	105.5km²
Constraint 1	96.7km²	-	-	101.9km²	103.5km²

Reactions of the Swiss electricity system: Power flow in time and space



Paper has too few dimensions: please check out our movies !!!

Conclusions & Outlook:

- Sizing and siting of PV installations to satisfy annual **average** demand is possible using available data, but temporally variable demand-supply mismatch remains.
- Next step: Include wind generation as additional resource to balance the intermitted production
- Investigate scenarios to stabilize the residual demand:
  - Increase pump storage capacity
  - Raise dams and explore other storage alternatives
  - Optimize Import/Export